

Detection and Classification of Buried Metallic Objects

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Metal locators have been used in archaeology and for the detection of mines and unexploded ordnance (UXO) for many years. These systems are sensitive but have not been very good at determining the depth, size, shape or metallic composition of an object. Consequently they cannot discriminate between desired targets and trash. The latter problem is of immense importance in the search for UXO since most of the time and effort involved is spent in carefully excavating non-UXO bits of metal. With this impetus considerable effort has been devoted to developing a next-generation metal locator for characterizing as well as locating metal objects. New systems arising from these efforts will be of use in archaeological studies.

We have found that detection and characterization of metallic objects can be considered as a two-step process. From our own model studies and the work of several others we found that the response of any target could be represented to first order by three orthogonal dipole moments, the Principal Dipole Moments (PDM). With this representation it is seen that it is necessary to have multiple polarizations of the search field to recover the orientation and multiple transmitter pairs to determine the location. The second stage is then to find the size, actual shape, and composition from the broadband time or frequency domain response.

In this study the role of transmitter-receiver configurations in the recovery of the location and attitude of a target is analyzed. We have developed an inversion code for determining the horizontal location, depth and the strength and orientation of the PDM for arbitrary positions of transmitters and receivers. Representative noise is added and the various configurations can be compared using the uncertainties in the estimated target parameters. As an example, this approach confirms the intuitive idea that adding an orthogonal receiver to the simple vertical coaxial loop-loop systems commonly in use greatly reduces the spatial sampling density required to recover target parameters. Multiple transmitters and receivers further increase the depth to which the attitude can be determined. The methodology can be applied to systems of any scale and system characteristics.

For the second stage, a spherical shell model illustrates the role of size, shell thickness, conductivity and magnetic permeability in the spectral response of the target.